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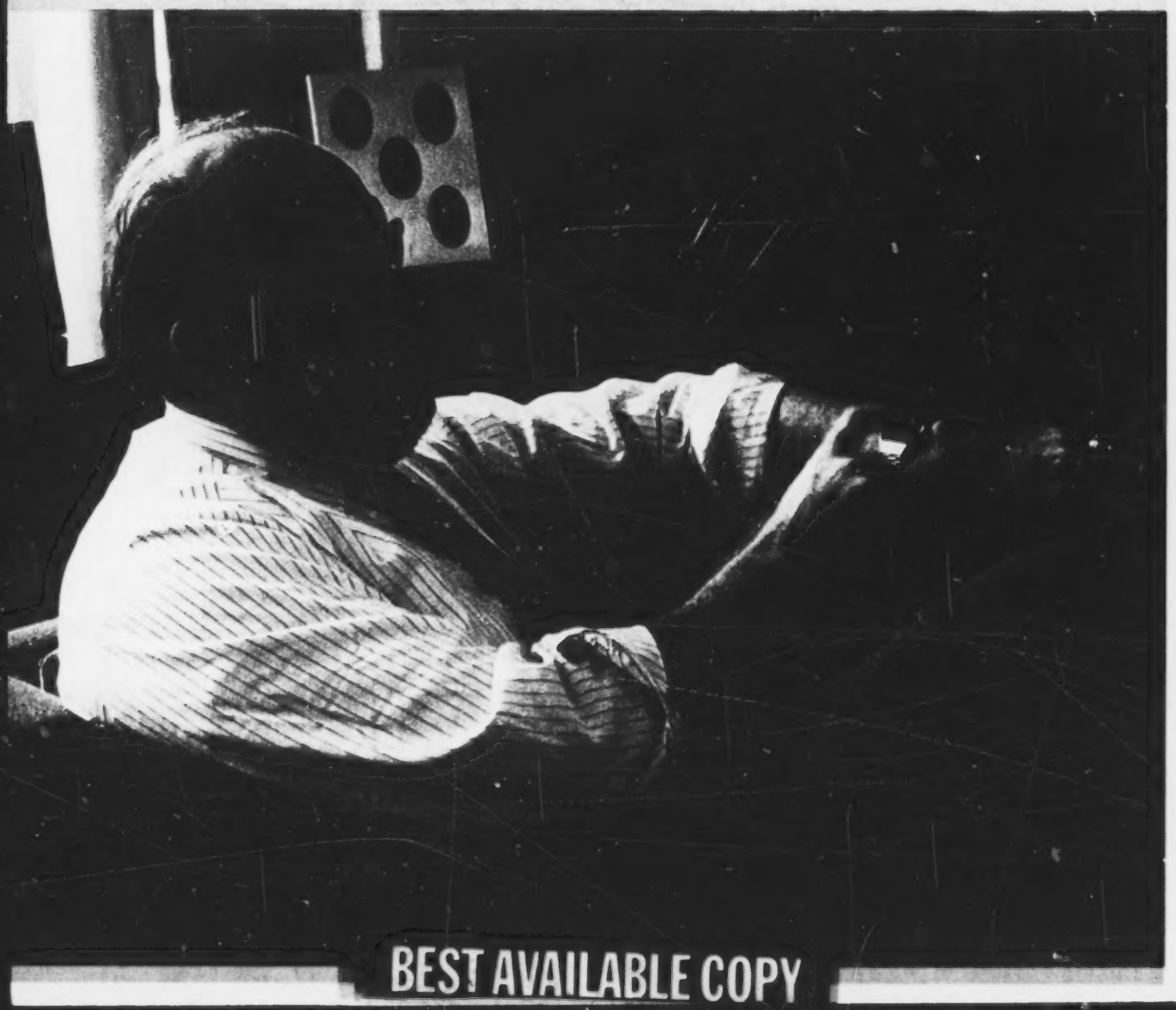

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The century of the satellite

Will 'leverage of specialization' replace 'economy of scale' as the linchpin of future telecom networks? Yes, says the author, and satellites will lead the way

Dr. Albert D. Wheelon

WE ARE living in a decade of extraordinary change driven by rapid advancements in the technology of computers and communications. This decade will set the direction and pace for the next century and will have a fundamental effect on every nation.

In the United States today, major telecommunications changes are occurring constantly. Computers and information are coming together in a way that demands new communication capabilities. Demand for new and more powerful communication service is accelerating. Vigorous new entrants are on the American communication scene. Evolving public attitudes toward television and telecommunications are beginning to influence national policy in important new ways. Competition is being tried on an increasingly wide scale, and is questioning the presumptive role of telecommunications monopolies.

The classic assumption of *economy of scale* is being challenged by the *leverage of specialization*. Leasing of communications facilities is developing as an important alternative to purchase. Sharing of facilities is increasing in place of exclusive ownership. Innovative financing of large telecommunications systems if beginning. Technology is creating opportunities for new services faster than public policy can be established to guide them comfortably. Let us look more carefully at these developments.

The Bell System provides the United States with an integrated telecommunications system of unusual capacity and quality. Ten years ago competition with this nationwide system of long lines facilities and local loops was not seriously considered. Yet today it is happening.

The first to compete were specialized microwave carriers which attempted to duplicate the terrestrial links of the Bell System on a selective basis. They soon found the capital requirements too large and the rewards too small. The next step was a new public policy requiring Bell to make its facilities available to competitive services. Opening the network to other users has produced a considerable amount of service innovation and has stimulated Bell itself in interesting ways. Its Advanced Communications Service is an example of Bell's response to the challenge of others.

The real agent of competition proved to be the communication satellite. With a satellite investment of $100 million or $200 million, a company could duplicate the long lines capacity of the terrestrial network. And this capacity could be operational in two or three years. With such a system, a competitor could provide service to as many points as desired with low cost earth stations. Public policy in the U.S. allowed, even tacitly encouraged, private companies to establish satellite systems at their own risk. Statistics on these systems are listed in Figure 1.

These systems have emerged since the U.S. government proclaimed its Open Skies Policy for domestic satellite communications in 1972. Their effect is pronounced. A rich fare of television programing is becoming available through a combination of satellites and cable TV systems. Communication services are being tailored to user's needs. The prospect of inexpensive, wideband data communications service is allowing the computer and office copier industry to take the next major steps in those technologies. Large companies are entering the communication equipment market in forceful and diversifed ways. The time scale for introducing new services is shortening dramatically under the press of competition.

There is another side to this competition. It is generally understood that a substantial amount of rate-averaging or cross-subsidy occurs in a monopoly network. Profitable long distance and business services generally support the not-so-profitable rural telecommunication systems. This is done as a matter of public policy. When a specialized carrier caters to the data needs of large industrial users, as SBS and Xerox propose to do, it may undercut the financial basis for public message service. On the other hand, if the specialized carrier provides new services that were not available for purchase from the monopoly network, they will not detract from the public

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message service. Both viewpoints have been argued, sometimes in disguised form.

This issue has a counterpart in satellite communications. INTELSAT now provides major path and primary service with the same spacecraft at the same rates. It is widely recognized that INTELSAT could provide the high density major path service between Europe and the United States with special purpose spot-beam satellites. It probably could do so at rates below the present structure and probably well below those charged for undersea cables. But that would imply costs of a different kind—opportunity costs for cable layers and possibly rate increases for the smaller users of INTELSAT. On the other hand, to ignore the opportunity for such specialization is to place a different—and possibly greater—burden on the system.

Another kind of satellite specialization is being considered by INTELSAT. It is based on the dissimilar geographical features and traffic demands of the three ocean basins. Thus far, identical satellites have been used in the three locations because the characteristics of all three satellites have been defined by the requirements of the Atlantic basin. Serious consideration now is being given to individualized and more appropriate satellites for each ocean basin. This new approach provides an interesting example of the leverage of specialization, in contrast to the economy of scale.

Satellite technology clearly provides the basis for communication specialization. However, it also supports the traditional economy of scale procedures for very important applications. For example, a spacecraft designed to provide standard coverage becomes progressively more efficient as more transponders are included. The new Hughes SYNCOM IV widebody spacecraft can accommodate as many as 48 transponders. It can do so at a much lower cost per transponder than the older 12 and 24 transponder satellites. Using appropriate financing arrangements, a satellite leasing company could allot three, six or twelve transponders to a small country, permitting it to realize the same low cost per transponder as a country that used all 48 transponders. By specializing its use of those transponders, the leasing nation could custom-tailor a satellite communications system fully responsive to its own requirements.

It is more economical to provide an additional unit of service with a network that already furnishes *similar service*, than it is to establish a new network. This practice forms the basis of incremental pricing. However, a *new kind of service* can be set up more cheaply as an independent module rather than as an increment to an existing network using common facilities. Recent experiments in the United States support this conclusion. The *leverage of specialization* is competing favorably with the *economy of scale* in the satellite era. It is a simple matter to specialize communication satellites, both in configuration and in service. Each satellite can be deployed in space as a module. Because of these technical advances, our economic theorems are changing. Those who cling to the *economy of scale* with common facilities may find themselves in increasingly awkward positions as the influence of satellites spreads. Whatever one's persuasion on the question of monopoly versus competition, no one can afford to ignore the leverage of specialization.

If one accepts the proposition that communication satellites are a major element in the emerging telecommunication model, it is important to understand where their technology and economics are leading. It is difficult to get one's bearings here because space technology has been glamorized by manned spaceflight and scientific expeditions to other planets. These ventures have colored the space industry with considerable romance. They also have invoked a high level of national prestige-consciousness.

We must look at satellites in a different light. We must realize that satellite systems can either frustrate or facilitate the provision of new services. They can provide more—or less—economical solutions to communication problems. They influence the price of communications both through their own costs and through the burden they place on ground stations.

Let us examine the costs of establishing satellite communication services in more detail. The direct cost of a satellite is composed of 1) the spacecraft itself, 2) its launch into geosynchronous orbit, and 3) insurance of the launch. The three elements invite careful attention. Spacecraft for telecommunications today cost $20 million to $30 million. They generally are procured on a firm fixed-price contractual basis. A substantial portion of the total price is paid only if the spacecraft perform satisfactorily in space for seven years or more. Financial penalties usually are incurred for late delivery. About half of the world's communication satellites have been procured by open competition and about half by negotiation. Most of the negotiated contracts were for standard spacecraft or modifications thereof. However, some operating companies have been unwilling to commit their communication traffic and revenue to a satellite chosen by the lowest bid price, and have retained their right to choose the best mixture of price and quality to meet their operational needs. For the most part, open competitions and price auctions prevail, and they have driven spacecraft prices to very attractive levels. This price reduction does not allow much international sharing of spacecraft development. There is considerable pressure to distribute satellite construction responsibilities; however, the relentless pressure of price competition has eliminated this practice except for a few international programs that are willing

FIG. 1 *U.S. domestic communications satellite systems.*

OPERATORS	START DATE	NO. OF SATELLITES	NO. OF CHANNELS	FREQUENCY GHz	BUILDER
ATT/GTE	1976	3	24	6/4	Hughes
Western Union	1974	3	12	6/4	Hughes
RCA	1976	2	24	6/4	RCA
SBS	1981	(3)	10	14/11	Hughes

NOTE: Xerox Corporation recently announced its intention to establish a nationwide satellite network.

and able to pay a surcharge for group comity.

The second important element of satellite system cost is the launch vehicle. All commercial communication satellites to date have been placed on orbit by either of two expendable U.S. rockets—the Delta and the Atlas Centaur. In 1970 the unit prices for these rockets were $5 million and $14 million, respectively. The prices will increase to $26 million for a Delta 3910-PAM and $40 million for an Atlas Centaur for launches in 1980. The rise reflects inflation and the approaching phase-out of these vehicles.

Three new launch systems are about to become operational: the U.S. Space Transportation System or Shuttle; the Japanese N-rocket and the European Ariane. The N-rocket is similar to the U.S. Thor Delta and is built under license in Japan. It has already flown from Tanegashima Island in Southern Japan, and takes a 300 lb. payload into synchronous orbit for a reported cost of $75 million. The Ariane is similar to the Atlas Centaur and can place about 2200 lbs. in geostationary orbit from a near-equatorial launch site in French Guiana. The first Ariane will be launched early in 1980 at a launch price of $15 million. Space Shuttle also will make its initial flight early in 1980. It will be launched from Florida and will place 65,000 lbs. into a low altitude earth orbit. To raise a communication satellite to geosychronous orbit, one of four payload assist modules must be used: (1) the PAM-D with an orbital payload of roughly 1240 lbs., (2) the PAM-A with a payload of 2290 lbs., (3) the Inertial Upper Stage (IUS) with a payload of 5000 lbs., or (4) integral propulsion system of SYNCOM 4 which allows a payload of about 3000 lbs. to be placed in orbit.

The cost of launching a 1240 lb. payload with the Shuttle and PAM-D in 1982 will be roughly $11 million. The cost of launching a larger satellite with integral propulsion, such as the 3000 lb. LEASAT, will be about $13 million in 1982.

The important point is that launch costs soon will drop significantly. This decrease is due primarily to the reusable feature of the Shuttle and the opportunity for ride-sharing offered by its large capacity. Ariane launches will be priced competitively with Shuttle launches to attract a share of the business.

Launch insurance is the third important element of satellite system cost. The threat of a launch loss is a financial burden that many system operators are unwilling to bear. To minimize this financial exposure, the London insurance market has offered launch insurance for over 10 years. The forms of available coverage have kept pace with the changes in technology. For the early INTELSAT launches, it was possible to obtain insurance only on the basis of large deductible losses. Moreover, the available insurance capacity for the early policies was less than $10 million, so only limited indemnifications could be provided. By comparison, full coverage of launch vehicle and satellite costs readily is available today with insurance capacity in excess of $50 million per launch. The current rate for expendable launch vehicles is less than 10% of the value insured, reflecting the 90% reliability of existing rockets. The corresponding rate for the Shuttle is expected to be significantly lower because of the improved reliability (98%) demanded by a vehicle transporting astronauts. The underwriters have yet to establish insurance rates for Ariane and the N-rocket.

A more recent development in the space insurance market is the variety of insurance for satellites' operational life. Owners of satellite systems now can protect themselves against partial failures or a total loss of communication capacity in orbit. The evolution of launch insurance and in-orbit life insurance has greatly reduced the financial risks of satellite ownership. These developments have all but removed the threat of major financial loss. They permit potential owners of satellite systems to concentrate implementation decisions on known cost factors and social benefits, rather than launch and operating risks.

Satellites' impact

The communication satellite exerts another major influence on the economics of telecommunications because its performance has direct impact on the ground segment. If the satellite is small and radiates a weak signal, the ground stations must be large and expensive. In a system with many ground stations, the total system cost can be increased disproportionately by economizing on the spacecraft. The opposite problem occurs if a very large, multipurpose satellite with high launch costs is chosen to operate with small, inexpensive earth stations. The apparent economy of scale associated with sharing the housekeeping functions on a large spacecraft easily can be overridden by the cost of completely replacing a complex satellite when only a few of its transponders have failed.

The system architect has the important responsibility of balancing the functions of the ground and space segments to reduce total system costs. A number of qualified consulting concerns offer system architectural service to potential system owners. Such counsel also can help a nation avoid uneconomic solutions to its telecommunication problems. The user can expect to feel considerable pressure from alliances of industries and nations committed to particular launch systems or satellite designs. The systems may or may not provide economic communications.

This point can be illustrated by comparing the Boeing 747 and Concorde airplanes. The first was developed with private funds in response to airline needs. The other was magnificent technology developed with government funding as a matter of national policy. As a technologist and frequent airline passenger, I am delighted that we have both aircraft. Air France and British Airways, who have operated the two aircraft, report profits on one and losses on the other.

The communication satellite field has had its economic disappointments. The AEROSAT program was largely conceived in an industrial and political context. It began as an expensive experiment in international space technology. The intended beneficiary, the airline community, took a dim view of the project. It expressed its opposition forcefully, and the program ended. Intrinsic economic viability is a requirement for communication satellites, just as it is for transport aircraft.

Satellite design should be driven by telecommunication needs, not the other way around. In the growing environment of service competition, the communication user who

chooses a noneconomic solution runs a considerable risk. High purchase, operating and replacement costs leave a communication system open to criticism, vulnerable to challenge, and in danger of displacement. Truly economic solutions are widely available using the most modern technology. They should be chosen competitively in preference to political solutions. The time necessary to explore the economic effects of alternate solutions well spent for the prospective system user.

Another important consideration for the prospective satellite user is system growth. Satellites have a finite lifetime. Batteries and tubes wear out in about seven years, just as the station-keeping propellant eventually is exhausted. A replacement satellite, probably ordered three years before, must be ready to launch at that point. Usually the traffic will have grown significantly in seven years and additional services will be required. This means that the new satellite will need more capability than its predecessor. Experience has shown that the technical and contractual definition of a second generation satellite usually is more difficult than that of its predessor. The satellite must meet a more complicated mixture of communication needs. It can be chosen from a richer array of space technology options. Like an airline, a communication entity must look to the future in choosing a satellite system supplier to ensure that the company will be vigorous and available for the next step in system growth.

The financial outlook

New financing forces are appearing on the telecommunication scene. Large sources of private capital in New York and Europe have become interested in satellite communications. For many years, these capital sources have financed transportation and other development projects. In the last two years, the world's large venture and investment capital managers have become comfortable with space technology. They now are convinced that telecommunication services via satellite present attractive investment opportunities.

One of the most interesting developments in the financing of satellite communications is the introduction of leasing. The application is similar to the aircraft industry and airlines. The titles to about half the world's commercial aircraft are held by groups of banks and investors. The airplanes are leased to the operating airlines. Satellite leasing works the same way. The difference is that the spacecraft is 22,000 miles above the earth. The legal question of title to the hardware that operates at such a great distance is a new but unimportant issue. Legal title has no effect on the telecommunication operator who provides service, or the investor/owners who provide the financing.

A more significant issue is the access to the nominal orbital position and frequency allocation coordinated through the international Telecommunications Union and used by the operating nation or International operator concerned. The general policy framework for using such resources is under discussion by the World Administrative Radio Conference in Geneva, Switzerland.

Leasing has the significant advantage for the operator of not requiring a large capital investment prior to start of service. That investment now can be made by the financial community. The operator pays for the service as it becomes available, and usually can cover this expense with operating revenues. The latter point may be an important advantage for developing nations.

Leasing has other advantages. While most contractors for purchasing satellites assign a fraction of the selling price to in-orbit performance, the majority of the financial risk is borne by the purchaser/operator. In the leasing arrangement, all the risk is borne by the seller/owner. The operator pays nothing until the satellite is operating in orbit according to contractual specification.

Leasing has a further advantage for the operator: it equalizes the outlay of investment capital. Satellite purchase requires a large amount of capital every five to ten years for replacement costs, with only small operating expenses in the meantime. The operator who leases service can budget a steady, predictable amount each year and thus avoid large capital appropriate swings. This plan has proved attractive to government agencies in the United States. It accounts for the satellite leasing programs of the U.S. Navy with Hughes and COMSAT and of NASA (National Aeronautic & Space Administration) with Western Union. It is likely that telecom administrations that depend on parliamentary appropriations will find leasing an interesting alternative to purchase/ownership.

A link exists between leasing and technology. Because the lessors bear the full risk of in-orbit performance, they usually insist on the most reliable technology. When COMSAT leased the Comstar satellite systems to Bell, it reserved the right to choose its own satellite supplier (Hughes) without competition, and to influence the spacecraft design significantly.

Leasing is proving popular for providing domestic satellite communication service also. INTELSAT is leasing transponders to its member nations at increasingly attractive rates. They provide this capacity with channels not immediately needed for international service. Individual members like Brazil and Nigeria use this leased capacity to establish domestic communications within their countries. Sixteen countries now lease transponders under this program, providing revenue to INTELSAT of $16 million per year. INTELSAT is considering the provision of backup capacity for these domestic channels, so that lessees can be sure their service will not be interrupted by other demands on the INTELSAT system. This program has substantial advantages and a small problem. Because INTELSAT is a respected international organization, it is in a favorable position to provide such service in an even-handed way. It can furnish the service on an incremental basis and thereby provide the economy of scale to its members-users. It clearly has the financial resources and operational experience to do so. Its present limitation is that it provides domestic service through satellites designed for global service and and located over the ocean centers. As a result, INTELSAT delivers a substantially weaker signal (22 dBw) than the domestic satellites currently operated by Canada, the United States, and Indo-

nesia (33 dBw). This power difference is significant and causes the earth stations to be approximately three times larger than those used with the domestic systems. INTELSAT therefore is considering the purchase of suitably modified international spacecraft or special satellites which can provide the higher signal level.

Share and share alike

This discussion leads us to consider another innovation in the era of satellite communications: facility sharing. Undersea cable capacity has been shared for many years, both in its ownership and its use. The Indefeasible Right of Use concept was developed by American Telephone & Telegraph Corp. to allow the U.S. international record carriers to participate in the benefits of partial cable ownership. Two of the three major satellite leasing programs in the United States are based on facilities sharing—carrying two different kinds of communication transponders on the same spacecraft. Sharing of satellite facilities by two or more countries is technically feasible and economically attractive. Indonesia has shared the use of the Palapa satellite with its neighbors in Southeast Asia on a lease basis. Interests of national prestige and priority of use in the event of satellite malfunction require careful consideration; however, sharing space facilities makes such good economic sense that it is sure to expand rapidly.

If leasing or sharing communication satellite facilities is not attractive, what about outright ownership? Prospects are excellent. Private loans from established sources are available in the United States, Europe and Canada. The U.S. Export-Import Bank (EXIM) has been active in arranging loans for satellite systems in foreign countries. It provided 45% of the financing for Indonesia's satellite system and guaranteed the 55% supplied by commercial banks. Export-Import loans usually carry a requirement that the funds be spent for U.S. equipment, as do other development banks. It also insists a positive evaluation of economic feasibility be provided in advance and that a consultant monitor the evolution of the system.

The counterparts of EXIM in other countries provide similar financing with attractive interest rates and "grace" periods for repayment. The World Bank has not yet expressed interest in these programs, but may change its priorities. For countries with heavy financial commitments or general credit problems, the U.S. Agency for International Development (AID) has already stated its willingness to support satellite projects that provide rural telephone service in developing nations.

Today the user of communications, rather than the supplier, is in the driver's seat. A complexity of choices is available today to the user, but he must choose wisely from this array. A nation new to telecommunications need not repeat all the steps in the development of telecommunications that have been taken in the past. A nation now can enter the process at the latest stage of evolution, and install a powerful, new satellite system suited to its own social and economic needs—and matched to its resources.

There are overriding advantages of communication satellite systems. Their cost in relation to capability is very small and affordable compared with the substantial cost of installing microwave plants throughout a country.

- They can be installed in two to three years.
- There is a variety of attractive ways to finance their purchase or lease.
- Reliable satellites are available competitively from several qualified suppliers around the world.
- They lend themselves both to *economy of scale* and to *leverage of specialization*, depending on design and system use.
- They can be procured on a fixed price basis.
- They provide communications solutions that can stand the test of long term economic viability.

In the next century we shall see a proliferation of specially tailored domestic and regional systems.

The next 100 years will be a century of competition. It will be a century of specialization. It will be the century of the satellite. And it will be a century of a most extraordinary expansion of telecommunications services. □

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